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Original Article

Geriatric Trauma in Patients ≧85 Years Old in an Urban District of Japan

Takeshi Nishimura[a,b], Hiromichi Naito[a]*, Shigenari Matsuyama[b], Satoshi Ishihara[b], Atsunori Nakao[a], and Shinichi Nakayama[b]

[a]*Department of Emergency and Critical Care Medicine, Okayama University Graduate School of Medicine, Dentistry and Pharmaceutical Sciences, Okayama 700-8558, Japan,*
[b]*Hyogo Emergency Medical Center, Kobe 651-0073, Japan*

Japan's population has been skewing toward the elderly, but the outcomes of advanced elderly trauma are not clear. Here we compared the outcomes of very elderly trauma patients (≧85 years old) with those of 65- to 84-year-old trauma patients. We retrospectively reviewed the medical records of patients treated at Hyogo Emergency Medical Center from August 2010 to August 2016; 631 patients were entered in the study. We divided them into the younger geriatrics (YG group, 65-84 years old: n=534) and older geriatrics (OG group, ≧85 years old: n=97). The group's patient characteristics, mortality, 1-year survival rate, and Barthel index were tabulated and compared. The patients' mean age was 75.6±7.5 years. There was no significant difference in mortality between the YG and OG groups (9.6% vs. 15.1%, odds ratio [OR] 1.73; 95% confidence interval [CI] 0.93-3.23, $p=0.083$). The 1-year survival rate (94.4% vs. 77.8%, OR 0.19, 95% CI 0.07-0.51; $p<0.01$) and Barthel index (Median score; 100 (IQR: 85-100) vs. 80 (IQR: 15-95), OR 0.98, 95% CI 0.97 to 0.99, $p<0.01$) differed significantly between the groups. Our study did not find a significant difference in-hospital mortality between patients in the YG group and those in the OG group.

Key words: aged, injury, mortality, morbidity, trauma

Japan' population has been skewing toward the elderly as the number of aged Japanese citizens continues to increase. In the 2015 Japanese National Survey, elderly people (defined as ≧65 years old) made up 26.6% of the total population, the highest rate since the survey began. In that survey by the Ministry of Internal Affairs and Communications, 3.9% of the total population was people ≧85 years old, which was the highest percentage among other developed countries <http://www.stat.go.jp/data/kokusei/2015/kekka/kihon1/pdf/gaiyou2.pdf> (accessed December 3, 2018.). Although 85 years old is older than the average Japanese life expectancy, the Ministry of Health, Labor and Welfare predicts that the life expectancy of Japanese will continue to increase in the future <https://www.mhlw.go.jp/toukei/saikin/hw/life/life17/dl/life17-15.pdf> (accessed December 3, 2018). As the nation with the greatest aging population, Japan thus faces several public health concerns related to the elderly and very elderly.

Despite many publications describing the mortality and morbidity of elderly patients, little research has been done on those 85 and older [1-3]. Aitken *et al.* reported the mortality of trauma patients in Australia, including patients ≧85 years. However, their study was based on different geriatric social circumstances and ethnic characteristics. The mortality and characteristics of trauma patients aged ≧85 years in Japan's aging society have not yet been sufficiently elucidated. We conducted the present study to describe the character-

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*Corresponding author. Phone: +81-86-235-7004; Fax: +81-86-251-7045
E-mail: naito05084@gmail.com (H. Naito)

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istics of trauma patients aged ≧65 years and compare the outcomes and complications of care between patients aged ≧85 years and those aged 65-84 years. We also evaluated the patients' 1-year survival rate and activities of daily living (ADLs).

Materials and Methods

Study design. We retrospectively reviewed all of the cases treated at a single emergency and critical care center from August 1, 2010 to August 31, 2016. The Hyogo Emergency Medical Center ethical committee approved the study (ID: 2017004). Inclusion criteria were trauma patients aged ≧65 years transported to our medical center. Exclusion criteria were as follows: patients with burn injury, cardiopulmonary arrest on arrival without the return of spontaneous circulation despite cardiopulmonary resuscitation, and patients with missing data.

Treatment. Hyogo Emergency Medical Center is one of two emergency and critical care medical centers in Kobe City, one of Japan's major metropolitan cities with a population of 1.5 million people.

Data collection. We obtained the following patient data were from the Medical Center's database: patient background, mechanism of injury, type of injury, emergent operation on arrival, length of hospital stay, length of intensive care unit (ICU) stay, Injury Severity Score (ISS), probability of survival (Ps) score, Glasgow Coma Scale (GCS) score, transfusion within 24 h, and complications such as pneumonia, urinary tract infection (UTI), and venous thromboembolism/pulmonary embolism (VTE/PE). Pneumonia and UTI were defined when the following conditions were completely met: the presence of clinical symptoms indicating infection, such as fever; evidence of bacteria detected in an examination; and antibiotic treatment evaluated by a clinician. Geriatric trauma patients were then divided into two groups; the younger geriatric patients group (YG group: 65-84-years-old) and the older geriatric patients group (OG group: 85 years old and older). We analyzed differences between the YG and OG groups were analyzed.

Information about the patient's 1-year survival rate and ADLs were gathered from surveys completed by survived patients or their nearby kin. ADLs were evaluated using the Barthel index, which includes 10 questionnaires asking about daily activities [4].

Statistical analyses. Continuous variables are described using the means and standard deviations (SD). Ordinal variables are presented using medians with interquartile ranges (IQR). Categorical variables are described using percentages. For the comparison of patient characteristics, we performed a univariable logistic regression was used to determine covariates associated with older geriatrics. We also performed a univariable logistic regression to compare the questionnaire results (1-year survival rates and Barthel index scores) of the older and younger groups. Then, to adjust covariates, we performed a multivariable logistic regression with the incident of in-hospital death as the dependent variable, and with age, gender, and ISS as the independent variables. The statistical analyses were performed using JMP® Pro11 (SAS institute Inc., Cary, NC, USA). A p-value below 0.05 was considered statistically significant.

Results

Characteristics of the trauma patients aged ≧65 years. Of the 2,913 trauma patients identified, 795 were aged ≧65 years. After excluding cases with cardiac arrest at arrival without recovery (62 cases), burns (43 cases), and cases without sufficient data (59 cases), 631 patients were enrolled in the study (Fig. 1).

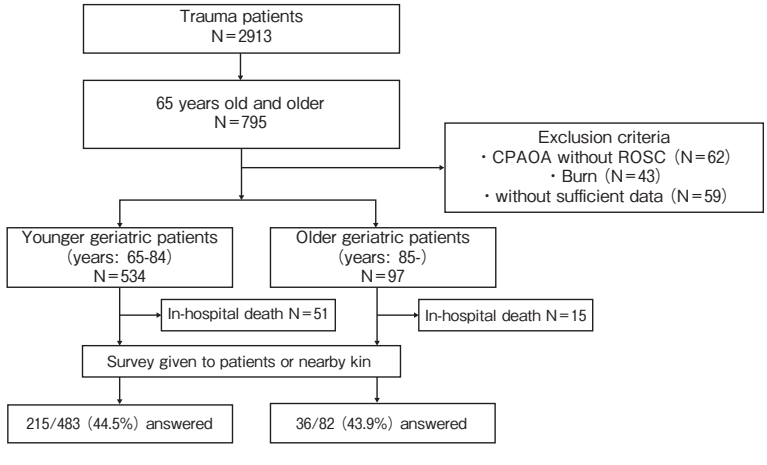

Fig. 1 Study population flowchart. CPAOA, cardiopulmonary arrest on arrival; ROSC, return of spontaneous circulation.

According to the one-year survival rate and Barthel index data, 251 questionnaires were valid, excluding the cases with in-hospital death.

The patients' characteristics and backgrounds are summarized in Table 1. The mean patient age was 75 years old (IQR: 69-81). There were 401 (63.5%) male cases and 230 (36.5%) female cases. The median GCS score on arrival was 14 (IQR: 13-15). The median ISS was 17 (IQR: 10-26), and the median Ps score was 0.92 (IQR: 0.76-0.96). The median length of hospital stay was 10 days (IQR: 3-20). The median length of ICU stay was 2 days (IQR: 1-5).

The incidences of emergency surgeries were as follows: craniotomy/trepanation (43 cases: 6.8%), thoracotomy (20 cases: 3.2%), laparotomy (53 cases: 8.4%), interventional radiology (75 cases: 11.9%), surgery for bone fracture (149 cases: 23.6%), and revascularization (11 cases: 1.4%).

Morbidity in the critical care unit was tabulated during hospitalization; pneumonia, UTI, and VTE/PE was presented in 79 cases (12.5%), 73 cases (11.6%), and 121 cases (19.2%), respectively.

Regarding mortality, while 565 patients (89.5%) survived, 66 (10.5%) died in the hospital.

The most common mechanism of injury was a traffic collision, including being hit as a pedestrian (286 cases; 45.3%), followed by slips and falls (237 cases; 37.6%). Stabbings and falls/impact from high places were involved in 57 cases (9%) and 21 cases (3.3%), respectively. Almost all cases involved a blunt injury (600 cases: 95.1%). A penetrating injury was involved in 31 cases (4.9%).

Comparison of the younger and older geriatrics. Table 2 summarizes the differences between the YG and OG groups. There were 534 patients in the YG group and 97 patients in the OG group. There was no significant difference between the 2 groups in baseline characteristics such as the ISS (odds ratio [OR] 1.00, 95% confidence interval [CI] 0.98-1.06, $p=0.84$), GCS (OR 1.01, 95% CI 0.93-1.06, $p=0.68$), and Ps (OR 1.02, 95% CI 0.43-2.38, $p=0.96$). The 2 groups' morbidity rates were also similar: pneumonia (OR 0.98, 95% CI 0.51-1.90, $p=0.96$), UTI (OR 0.97, 95% CI 0.49-1.92, $p=0.97$), and VTE/PE (OR 1.48, 95% CI 0.89-2.47, $p=0.13$). There was no significant difference in mortality between the YG and OG groups (OR 1.73, 95% CI 0.93-3.23, $p=0.083$).

Surveys were obtained from 215 of 483 cases (44.5%)

Table 1 Characteristics and epidemiology of the enrolled trauma patients

		n = 631
Age-years		
	Median (IQR)	75 (69–81)
Gender (%)		
	Male	401 (63.5)
	Female	230 (36.5)
GCS		
	Median (IQR)	14 (13–15)
ISS		
	Median (IQR)	17 (10–26)
Ps		
	Median (IQR)	0.92 (0.76–0.96)
LOH		
	Median (IQR)	10 (3–20)
Length of ICU stay (days)		
	Median (IQR)	2 (1–5)
Transfusion within 24 h (%)		194 (30.7)
Emergency surgery (%)		
	Craniotomy/Trepanation	43 (6.8)
	Thoracotomy	20 (3.2)
	Laparotomy	53 (8.4)
	IVR	75 (11.9)
	Bone fracture	149 (23.6)
	Revascularization	11 (1.4)
Complications (%)		
	Pneumonia	79 (12.5)
	UTI	73 (11.6)
	VTE/PE	121 (19.2)
Prognosis (%)		
	Survival	565 (89.5)
	Death	66 (10.5)
Mechanism of Injury (%)		
	Traffic collision	286 (45.3)
	Slip	237 (37.6)
	Stab	57 (9)
	Fall	21 (3.3)
	Other	30
Type of injury (%)		
	Blunt	600 (95.1)
	Penetrating	31 (4.9)

IQR, interquartile range; GCS, Glasgow Coma Scale; ISS, Injury Severity Score; Ps, probability of survival; LOH, length of hospital stay; ICU, intensive care unit; IVR, interventional radiology; UTI, urinary tract infection; VTE/PE, venous thromboembolism/pulmonary embolism.

Table 2 Comparison between the younger geriatric trauma patient group and the older geriatric patient group

		Young geriatric group, 65–84 years old (N = 534)	Older geriatric group, ≧ 85 years old (N = 97)	Odds ratio (95% CI)	*p*-value
Age-years					
	Median (IQR)	73 (69–78)	87 (86–89)	–	–
Gender (%)					
	Female/Male	181/353	49/48	1.99 (1.29–3.08)	< 0.01
ISS					
	Median (IQR)	17 (10–26)	18 (10–26)	1.00 (0.98–1.06)	0.84
GCS					
	Median (IQR)	14 (13–15)	14 (13–15)	1.01 (0.93–1.06)	0.68
Ps					
	Median (IQR)	0.92 (0.73–0.96)	0.92 (0.77–0.96)	1.02 (0.43–2.38)	0.96
Complications (%)					
	Pneumonia	67 (12.6)	12 (12.4)	0.98 (0.51–1.90)	0.96
	UTI	62 (11.6)	11 (11.3)	0.97 (0.49–1.92)	0.94
	VTE/PE	97 (18.2)	24 (24.7)	1.48 (0.89–2.47)	0.13
Mortality (%)		51 (9.6)	15 (15.5)	1.73 (0.93–3.23)	0.083
LOH					
	Median (IQR)	10 (4–20)	7 (2–17)	0.99 (0.97–1.00)	0.16
Length of ICU (day)					
	Median (IQR)	2 (1–5)	2 (1–6)	1.00 (0.96–1.03)	0.87
Transfusion within 24 h (%)		159 (29.8)	35 (36.1)	1.33 (0.85–2.10)	0.22
Emergency Surgery (%)					
	Craniotomy/Trepanation	36 (6.7)	7 (7.2)	1.08 (0.43–2.35)	0.87
	Thoracotomy	16 (3)	4 (4.1)	1.39 (0.39–3.90)	0.57
	Laparotomy	49 (9.2)	4 (4.1)	0.43 (0.13–1.08)	0.07
	IVR	65 (12.3)	10 (10.3)	0.83 (0.39–1.61)	0.60
	Bone Fracture	132 (24.7)	17 (17.5)	0.65 (0.37–1.13)	0.11
	Revascularization	9 (1.7)	2 (2.1)	1.23 (0.26–5.77)	0.80

IQR, interquartile range; CI, confidence interval; GCS, Glasgow Coma Scale score; ISS, Injury Severity Score; Ps, probability of survival; LOH, length of hospital stay; ICU, intensive care unit; IVR, interventional radiology; UTI, urinary tract infection; VTE/PE, venous thrombosis/pulmonary embolism.

in the YG group and 36 of 82 cases (43.9%) in the OG group (Table 3). The 1-year survival rate was 203 of 215 patients (94.4%) in the YG group and 28 of 36 patients (77.8%) in the OG group, respectively (OR 0.21, 95% CI 0.08-0.55, $p < 0.01$). Our comparison of 1-year Barthel index scores also revealed a significant difference; the median score was 100 (IQR: 85-100) in the YG group and 80 in the OG group (IQR: 15-95) (OR 0.98, 95% CI 0.97-0.99, $p < 0.01$).

For a logistic regression analysis to detect risk factors for in-hospital mortality (Table 4), we divided the ISS scores into 2 groups (≧16 and <16). Although the results showed that a high ISS was a crucial factor for mortality (OR 14.2, 95% CI 5.18-58.9, $p < 0.01$), age was not a significant factor (OR 1.90, 95% CI 0.97-3.58, $p = 0.06$).

Discussion

Mortality did not statistically differ between the YG

Table 3 Comparison of 1-year survival rates and Barthel index scores

	Younger geriatric group (N = 215)	Older geriatric group (N = 36)	Odds ratio (95%CI)	*p*-value
1-year survival No. (%)	203 (94.4)	28 (77.8)	0.21 (0.08–0.55)	< 0.01
Barthel Index of survivor, median (IQR)	100 (85–100)	80 (15–95)	0.98 (0.97–0.99)	< 0.01

Table 4 Logistic regression analysis for in-hospital mortality

	Multivariable analysis	
	Odds ratio (95%CI)	*p*-value
Age		
Younger (65–84)	Reference	–
Older (≧85)	1.90 (0.97–3.58)	0.06
Gender		
Female	Reference	–
Male	0.91 (0.53–1.59)	0.73
ISS		
less than 16	Reference	–
≧16	14.2 (5.18–58.9)	< 0.01

and OG groups. The respective rates of the occurrence of morbidities were similar between groups. It has been reported that complications following admission for trauma injury, especially for elderly patients with increased age, are frequent [5]. Geriatric patients hospitalized for traumatic injury had more variation in complexity compared to the cases of younger patients. Some cases had unfavorable clinical outcomes. Aitken *et al.* described the characteristics and outcomes of injured adult patients aged ≧65 after hospital admission in Australia [3]. They reported that male gender, older age, ICU admission, higher ISS, injury caused by a fall, and 2 or more injuries were predictors of death.

However, the prior studies focused on young geriatrics, including only a small number of very elderly subjects. The possibility of improving geriatric trauma outcome has recently become a research focus. Hammer *et al.* described a method mandating that the highest level I trauma is activated for all injured patients aged ≧70 years upon emergency department arrival, which led to decreased mortality [6].

Prin *et al.* reported that the most common complication in patients admitted to the ICU in the United States was UTI [7]. Zielinski *et al.* and Polites *et al.* described their analyses of UTIs in elderly trauma patients from a trauma database [8,9], and they noted that a longer hospital stay had a serious impact on the development of UTIs in geriatric trauma patients. Pneumonia, whether ventilator-associated or not, is another important complication. Magnotti *et al.* described ventilator-associated pneumonia among patients admitted to trauma intensive car with ISS scores < 25 to a level I trauma center [10]. They reported that the incidence of ventilator-associated pneumonia was 8%, and increased age, larger amount of transfusion, higher ISS, lower GCS score, and chest injury were risk factors. The incidence of post-injury pneumonia in the ICU described by Hyllienmark *et al.* was 26%; shock, intubation in the field, low GCS score, major surgery, ISS > 24, and massive transfusion were all risk factors for the ensuing development of pneumonia [11]. In the present study, pneumonia occurred in 12.5% of the patients, UTI was documented in 11.6%, and VTE/PE occurred in 19.2%. Prin *et al.* reported that these complications occurred in 4.7%, 10.9%, and 4.2% of patients of all ages, respectively, at Level I and II trauma centers [7].

Our aged patients seemed to have more complications than those described in the Prin *et al.* study, which included a much younger population. At our facility, VTE in the lower limbs is thoroughly screened within 7 days of admission by ultrasonography, and VTE was detected in 19.2% of the present study's patients during the examination. The incidence of VTE in our aged trauma patients was higher compared to that in the previous study [7]. Advanced geriatrics may have a greater incidence of VTE, however, some patients could have VTE before hospitalization.

In the United States National Trauma Databank, 1.4% of the patients acquired sepsis with an approximately 20% associated mortality [12]. Male gender, age, African-American race, hypotension at emergency department admission, and injury caused by a motor vehicle crash were independently associated with post-traumatic sepsis. Epidemiology and risk factors

for sepsis after multiple traumas were also assessed in patients of German descent [13]. In that study, the incidence of sepsis in the trauma ICU decreased significantly, although there was no significant decrease in mortality in septic trauma patients. The incidence of sepsis caused by pneumonia in our present study was low (5 cases: 0.79%), which may have affected the similar complication rates and mortalities in the YG and OG groups.

ICU management concepts and years of experience are reported to be important factors. Bukur *et al.* reported that compared to mixed function ICU, a dedicated trauma ICU had a significantly lower complication rate (27.5% vs. 17.0%, $p<0.0001$) as well as death rate after complication (3.7% vs. 1.8%, $p<0.001$) [14]. The use of a bundled checklist with physician confirmation may reduce the risk of nosocomial complications in trauma patients [15]. Joseph *et al.* reported that the frailty index by Seaele [16] was an independent predictable factor of complications and adverse discharge disposition in geriatric trauma patients [17].

Although mortality was low in both of our present geriatric groups without a significant difference, the 1-year survival rate and ADL score in the OG group were not improved in our study. We maintain that aging had a strong negative influence on long-term outcomes, but short-time outcomes (in-hospital mortality) were not influenced by aging. The result of our study suggests that Japanese facilities that are specialized in trauma care may satisfactorily save older geriatrics as well as younger geriatrics.

Strength and limitations. This is the first study to reveal a difference in mortality among geriatric trauma patients with related 1-year survival rates and 1-year ADL data in Japan. The findings from this study could be important in the field of geriatric trauma care.

However, our study has several limitations. First, this was a retrospective analysis, which may be vulnerable to information bias. Second, the patients were admitted at a single center, and thus our findings might not be applicable or relevant to other facilities. Third, the low return rate of the 1-year survival/Barthel index survey might have affected the results as selection bias. We could not obtain surveys from deceased patients, and it is assumed to be easier for surviving patients or their families to answer the questionnaires compared to deceased patients' nearby kin. Fourth, the total number of patients with trauma injury was smaller than in a previous study of geriatric trauma patients. Fifth, gunshot and stab wounds are rare in Japan; the most typical types of injury are slip/falls and traffic accidents. This might have affected the mortality results. Sixth, the percentage of male patients was higher in the YG group. Although the multivariable logistic regression analysis was performed to eliminate the difference in gender, this may have caused the YG group to have a higher mortality rate, as male gender generally can be a risk factor for mortality. Finally, we did not analyze the site of injury or the patient's ADLs before the trauma/accident. These factors were residual confounders, which should be considered in the future studies for further analyses.

In conclusion, in-hospital mortality and morbidities did not significantly differ between trauma patients 65-84-years-old and those $\geqq 85$. This result should encourage clinicians treating geriatric trauma cases.

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